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A RESTRAINT CHAIR WITH ROWING-LIKE MOVEMENT FOR EXPOSING EXERCISING NONHUMAN PRIMATES TO MICROWAVE IRRADIATION

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SUMMARY PAGE

THE PROBLEM

At this laboratory a research program is underway to investigate the biological effects of microwave radiation. The protocol requires that rhesus monkeys be comfortably restrained and also be free to manipulate some parts of the experimental apparatus. Electrical properties of the materials from which the restraining device is constructed must be such that it does not interfere with the microwave energy distribution. This problem had been reasonably solved for those experiments requiring the animal to perform a simple lever press or button push. A new experiment was designed requiring a pillory-type restraining device that would allow the animal to perform external work of sufficient magnitude and rate that significant amounts of metabolic heat would be generated.

FINDINGS

In previous experiments the problem had been solved by using Styrofoam as the basic raw material in fabricating restraint chairs that held the animal at the neck and waist. This general design was substantially modified to include a large vertical lever on each side of the chair. These levers were pivoted at the center and attached to each other by a horizontal bar at the bottom of the levers. A short horizontal bar was attached to the inside of each lever at the upper end. The upper bars were grasped by the hands and a lower bar by the feet. The animal could then perform a rowing-like movement by pulling the upper bar and pushing the lower bar. This device was then connected by a cable and pully to an external load. Illustrative base-line experimental results using this exercise chair are given.

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The animals used in this study were handled in accordance with the principles stated in the "Guide for the Care and Use of Laboratory Animals," Committee on Revision of the Guide for Laboratory Animal Facilities and Care, Institute of Laboratory Animal Resources, National Research Council, DHEW Publication No. (NIH) 80-23, 1980.

INTRODUCTION

At this laboratory a research program is underway to investigate the biological effects of microwave radiation. The protocol requires that rhesus monkeys (Macaca mulatta) be comfortably restrained and also be free to manipulate specific parts of the experimental apparatus. Electrical properties of the materials from which the restraining device is constructed must be such that it does not interfere with the distribution of the incident microwave energy. This problem has been reasonably solved for those experiments requiring the animal to perform a simple lever press or button push (17). As a part of this research program on microwave effects, an experiment has been designed that will test the hypothesis that metabolic heat produced by exercise and heat produced by absorption of microwave radiation combine in such a way that the animal is less tolerant to absorbed microwave energy while he is engaged in strenuous work. To test this hypothesis a restraining device was required that would allow the animal to perform external work of sufficient magnitude and rate that he would generate significant amounts of heat.

Various techniques have been developed for exercising macaques: utilizing restraint chair with a T-bar pulled by the hands, (8, 9), restraint chair with wheel turned by the feet (16, 20), large squirrel cage (5), treadmill (19), restraint chair with a spring-loaded footrest (3, 22) and calisthenics (6, 7). The basic design of our prototype for this new device evolved from the pillory-type restraint chairs described by Mason (14) and Young (23), Gisolfi et al's restraint chair and rocker arm with hand and foot bars (10), and our laboratory's prior experience in the fabrication of Styrofoam restraint chairs (17, 18). This combination resulted in an exercise device that maintained the exercising animal in a fixed position and caused minimal perturbation of the microwave field intensity pattern about the animal.

An initial chair was constructed of Plexiglas establishing the basic concepts and mechanical arrangements. From this model a final chair was made of Styrofoam and high impact styrene for exposing monkeys in a microwave-anechoic irradiation chamber. Illustrated in Figure 1 the monkey "rowed" on centrally-pivoted side levers that were connected by foot and bottom bars and by the latter bar to a spring work load.

The operational exercise restraint chair proved satisfactory for both (a) operant conditioning of exercise behavior that produced an increase in body temperature at varying force levels and (b) allowing tolerable microwave transparency. The animal exercised by making rowing-like movements, mainly, by pulling of separate handle bars and to a lesser extent, by pushing of feet on a foot bar. Each rowing-like movement (a) extended a reel spring and (b) activated switches that signaled a correct response. The number of correct responses (complete rowing-like movements) required for a food pellet reinforcement could be varied. The pellet was delivered from his left through a feeding tube. Minimal energy expenditure was calculated from the response rate and extension of the reel spring. Physiological and behavioral parameters of colonic temperature, heart rate, response rate, interresponse time and post-reinforcement pause time

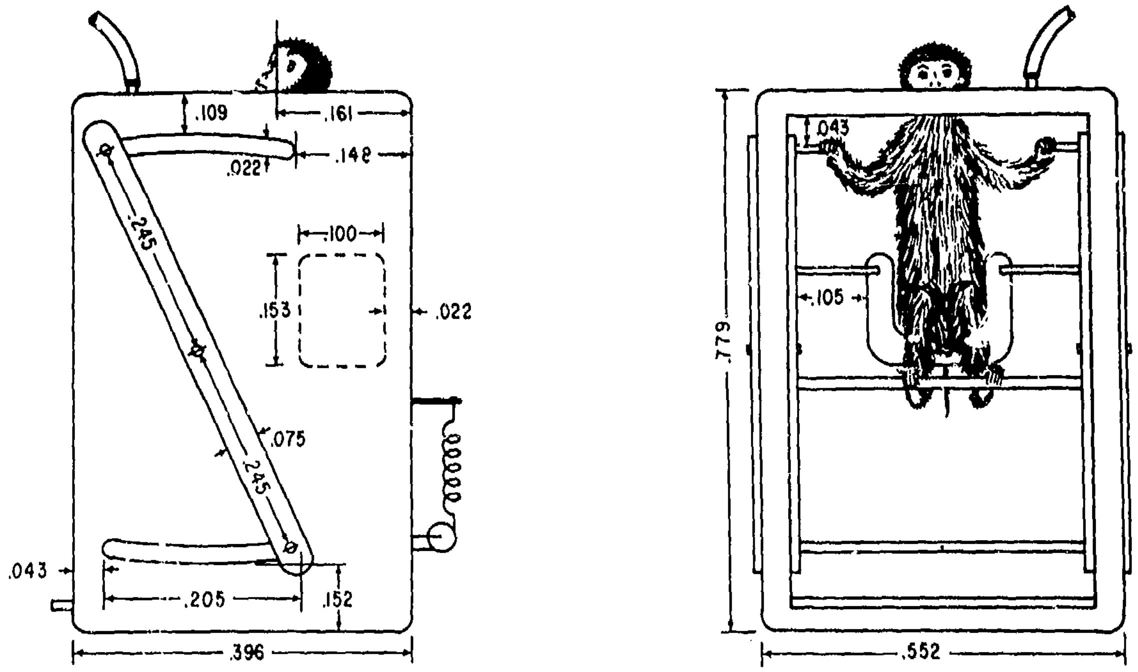


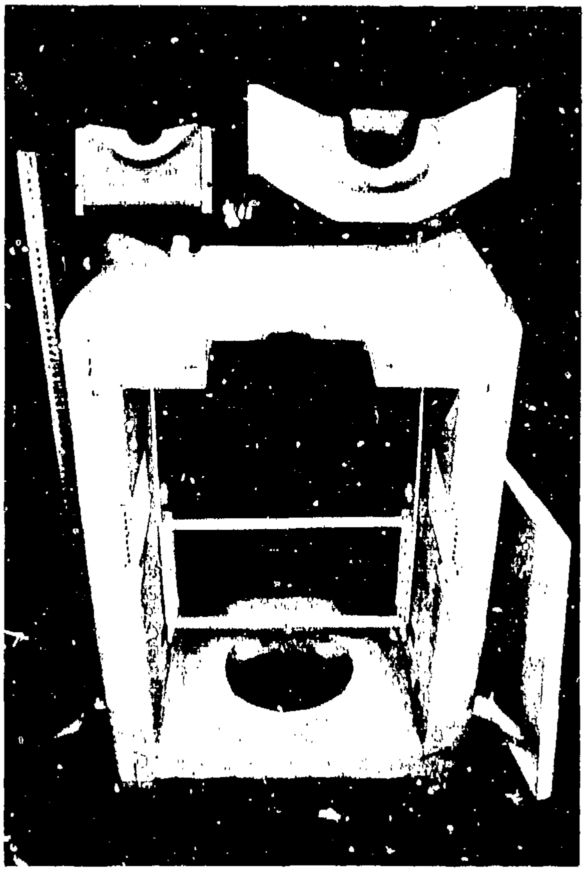
Figure 1

Lateral and frontal diagrams showing general construction of rhesus monkey exercise chair apparatus with dimensions given in meters.

were recorded. Microwave power density measures were made to (a) evaluate the chair's degree of microwave interference and to (b) calculate microwave absorption by the animal. An example experiment is presented that used data from a series of sessions that established a base line of physiological and behavioral values prior to a microwave irradiation experiment. This application of the microwave-exercise chair proved very successful.

DESIGN AND CONSTRUCTION OF THE MICROWAVE-EXERCISE CHAIR

Principal parts of the microwave-exercise chair (Figure 2a) were cut from 3-inch sheets of Styrofoam HD-300 (Hibco Plastics Company, Yadkinville, North Carolina). At places on the chair where use would quickly erode the Styrofoam, a high impact styrene, Styronol (Norton Plastics and Synthetics Division, Conneaut, Ohio), was shaped and bonded to it with Epoxi-Patch (The Dexter Corporation, Olean, New York). The levers, handles, bars, seat latches, seat shelves, feeding elbow, cable attachment, and waste tray were made from high impact styrene. The feeding tube was of polyvinyl chloride (PVC), and the nuts and bolts were of nylon. A strap of Velcro (Velcro USA, Inc, Manchester, New Hampshire) around the monkey's waist kept him secure in a sitting position at all times. Velcro was also used at the chair's base to secure it to Styrofoam support rails which were fixed in position in the irradiation chamber.



a. b.

Figure 2 a. Rear view of the assembled Styrofoam exercise chair for a rhesus monkey. The meterstick indicates relative dimensions.
b. Dismantled Styrofoam exercise chair.

Figure 2b shows a rear view of the exercise chair with its component parts separated. These parts are reassembled during the restraining process which required that the monkey be held and his neck placed first into the front half of the collar at the top of the chair and then the back half of the collar (shown in Figure 2b at top left) inserted into the styrene slide and gently pushed forward so that it enclosed his neck. The back half of the collar was held in place by the two pins shown in Figure 2b, at the top. The pins were made from a combination of threaded nylon and teflon. Next, the seat (at right top in Figure 2b) was inserted into the appropriate seat shelves in the middle of the back side of the chair and held securely by a latch on each side. The strap was then put around the monkey's waist and fastened to the back of the seat. The waste tray at the right of the chair in Figure 2b had a circular piece of styrene affixed to the bottom that fit into the large hole in the base of the chair. Food pellets from an automatic feeder were delivered through tubing connected to the styrene elbow. The monkey obtained the pellets from the circular trough in front of his mouth with lip and tongue manipulations.

Figure 3 shows two views of the chair with a monkey in place. Note in Figure 3b that the plastic cable attached to the lower bar of the chair passes through the rear of the microwave chamber through a 1/2 inch styrene flared tube and then, as shown in Figure 4a, is attached to the bottom end of a styrene bar which in turn is connected to the reel spring. Details of the reel spring assembly and attachment to the sliding bar are shown in Figure 4b. Detents on the styrene bar activated the microswitches only when the device moved through its full travel. These switches allowed working activity to be recorded. Full extension of the reel spring by the monkey was 17 cm. Reel springs of different spring constants (work loads) were used to vary the exercise effort required of the subject.

a. b.

Figure 3 a. Rhesus monkey ready to exercise inside the microwave exposure chamber, showing position for rowing-type exercise.
b. Detailed view of the exercise chair's functional components.

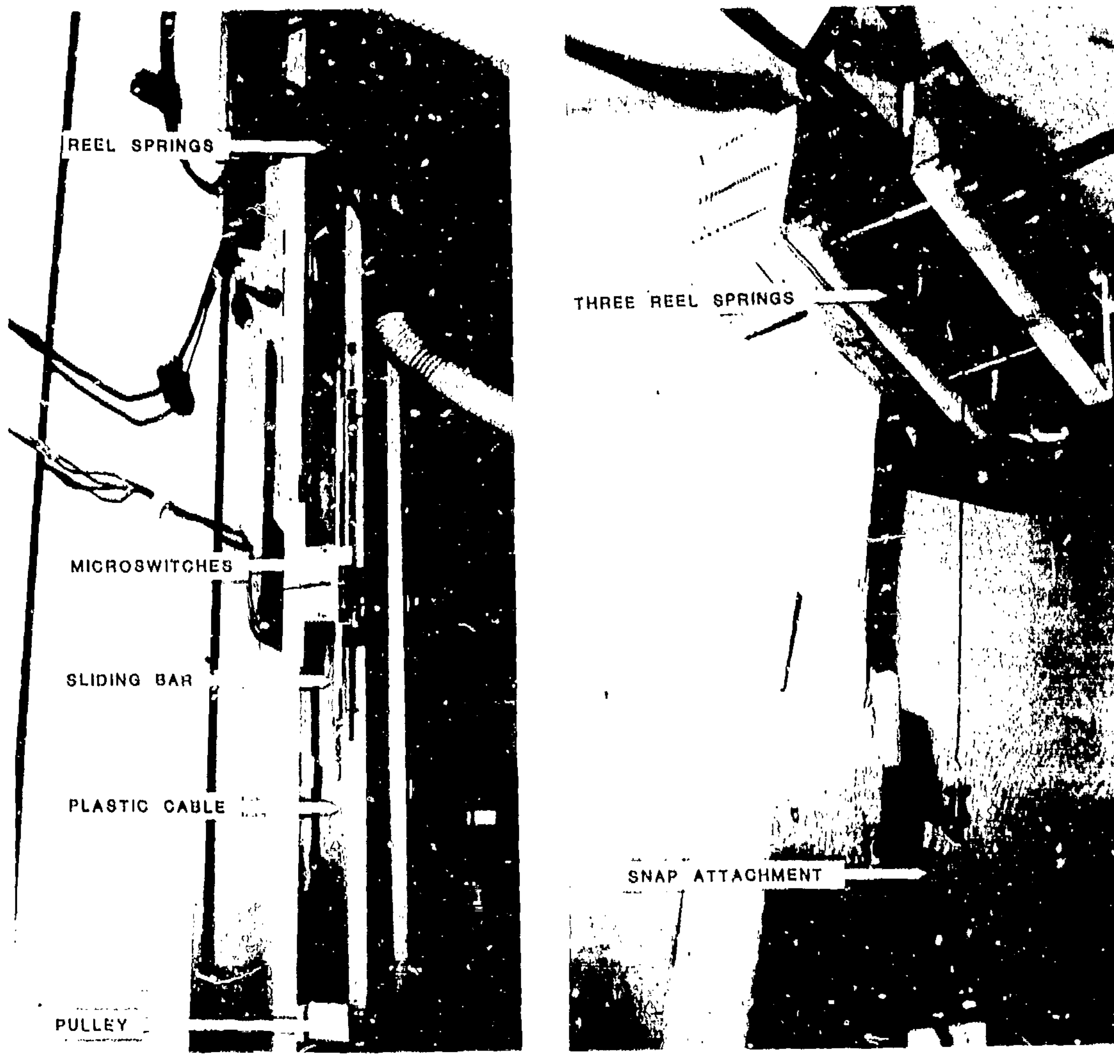


Figure 4 a. Outside rear wall of microwave exposure chamber showing the reel spring work load apparatus.
b. Close-up of the reel spring assembly and cable attachment to upper end of the sliding bar.

MICROWAVE PERTURBATION EFFECTS OF THE CHAIR IN ABSENCE OF THE ANIMAL

To determine the degree of chair perturbation of the microwaves, two kinds of field measurements were made. One was made at different body positions, first, with the chair in position and then with the chair removed. The other measurement was a vertical scan of the power density, first, behind the chair and then with the chair removed. A Narda microline isotropic probe (model 8323, Narda Microwave Corp., Plainview, New York) was the sensor for the power density readings (E field polarization) of pulsed 1.28 GHz microwaves. When the chair was used for irradiation measurements it was always positioned so that the animal faced the radiation horn.

The body position microwave measurements were made in the near field (minimum far field distance = 169 cm from horn) and the anterior muzzle (snout) position of the monkey was 102 cm from the center of the radiation aperture. It is seen from the data given in Table I that with removal of the chair only a slight field change occurred at the upper three body positions but at the foot position there was a notable difference.

TABLE I. Microwave measurements with chair (no monkey) and without chair

Location of measurement point	Power density (mW/cm^2)	
	with chair	without chair
Muzzle	51	50
Chest	46	44
Abdomen	32	33
Feet	27	22

The vertical scan measurements were at 145 and 176 cm from the horn's front center. The vertical scans were centered on the horn axis and were made from 20 cm above to 20 cm below the axis in 5 cm increments. If an animal were in the chair his muzzle would have been on the horn center line. Power density readings were made with the rear of the chair 22 cm closer to the radiation horn. The values in Table II show that the top of the chair has the least microwave field disturbances, while from the neck area downward the presence of the chair perturbed the field to a much greater extent, especially in the near field.

EXAMPLE EXPERIMENT AND DISCUSSION

In preparation for exposure of a group of four rhesus monkeys to pulsed 1.28 GHz microwaves it was necessary to establish a base line of stable operant performance of the monkeys to an exercise regimen while they were restrained in the Styrofoam exercise chair. An 84-minute experimental session was imposed daily on the animals. Three different work loads were assessed during a session. Figure 5 is an outline of the session schedule and its eight subunits termed components, are identified. The pre-and post-sessions, and exercise components were 15 minutes each; the extinction components were 3 minutes each. The food pellet feeder, the correct response signal (an auditory stimulus), and the room lights were off during the pre-and post-sessions and extinction components.

Reel springs (Part number ML-3949, Ametek, Hatfield, Pennsylvania) seen mounted outside the microwave chamber in Figure 4 served as the force moved (work load) by the monkey during exercise. Figure 6 illustrates the manufacturer's calibration data for these springs and that extension of the reel spring cable requires approximately 5 grams per centimeter greater force than the initial force (675 g).

TABLE II. Vertical mean power density measurements and perturbation ratios with (no monkey) and without the chair between the measuring probe and the radiation aperature.

	cm	body position	Horn-Probe distance: 145 cm, mW/cm² with chair	Horn-Probe distance: 145 cm, mW/cm² without chair	Horn-Probe distance: 145 cm, chair induced change	Horn-Probe distance: 176 cm, mW/cm² with chair	Horn-Probe distance: 176 cm, mW/cm² without chair	Horn-Probe distance: 176 cm, chair induced change
ABOVE CENTER LINE	20		26	28	-7%	19	20	-5%
	15		27	30	-10%	19	20	-5%
	10		28	32	-12%	19	21	-10%
	5	(Top of Head)	31	36	-14%	20	22	-9%
RADIATION-HORN CENTER LINE	0	(Muzzle)	37	38	-3%	24	24	0%
BELOW CENTER LINE	5	(Neck)	33	42	-21%	24	25	-4%
	10	(Shoulder)	30	39	-23%	19	22	-14%
	15	(Chest)	24	36	-33%	13	21	-38%
	20	(Abdomen)	16	33	-52%	8	19	-58%

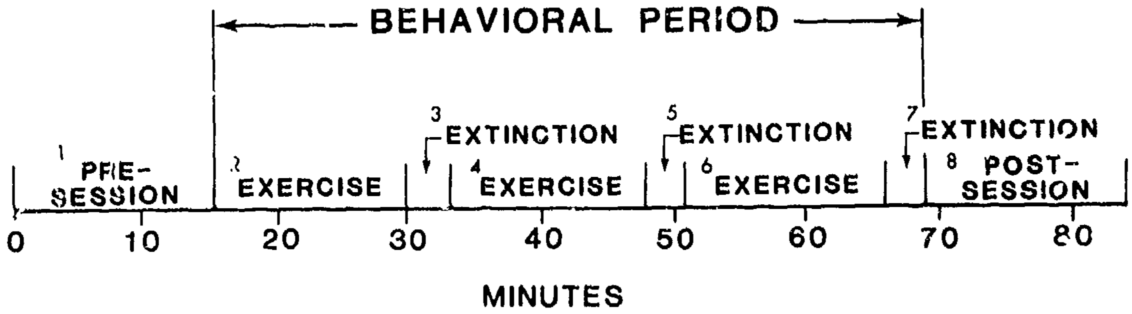


Figure 5

Multiple random ratio schedule (MRR) for exercising rhesus monkeys. The MRR is divided into 8 components (each component identified by a number). Different work loads are used during the exercise components. During the non-exercising components, the room light is out, the feeder does not operate and the correct response feedback signal does not sound.

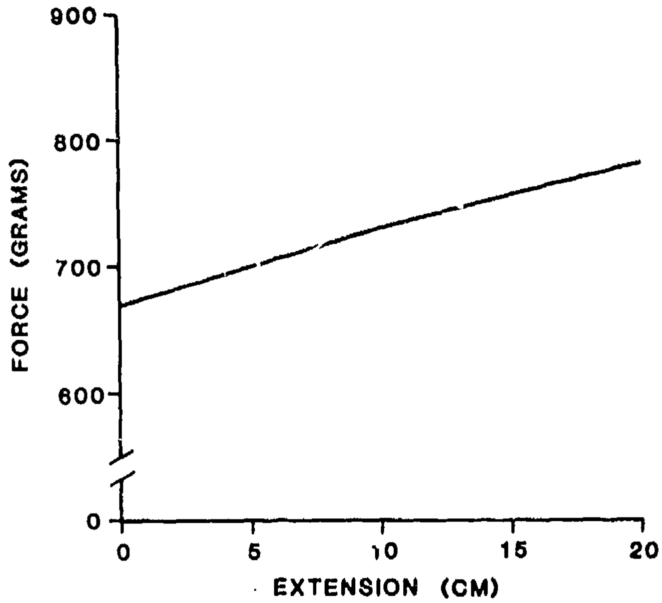


Figure 6

Manufacturer's calibration data for work load reel springs of Figure 4b. This illustrates that a force of 700 grams when the spring is extended to 5 cm only changes to 750 grams at a 16 cm extension.

The base-line data and findings from rhesus monkey 15R are presented to exemplify the satisfactory application of the Styrofoam exercise chair. He required only 5 training sessions to develop an adequate rowing-like movement.

Figure 7 shows the exterior of the microwave chamber with the door open to show the exercise chair secured to rails with Velcro straps. The feeding tube, seen joined to the top of the chair, delivered food pellets from a feeder mounted on the outside of the chamber. Figure 8 is a view inside the microwave irradiation chamber with irradiation horn, monkey feeding tube, and exercise chair positioned for the experiment. The exposure chamber is equipped with a closed-circuit television camera to monitor the animal, speakers (one for white noise and the other for the correct response auditory stimulus), lights and an ambient temperature probe. Ventilation fans and air conditioning unit are on the outside of the chamber. Computer-operated control and recording equipment are located in an adjoining room. Stimulus and response contingencies are mediated by electromechanical and solid state switching circuitry.

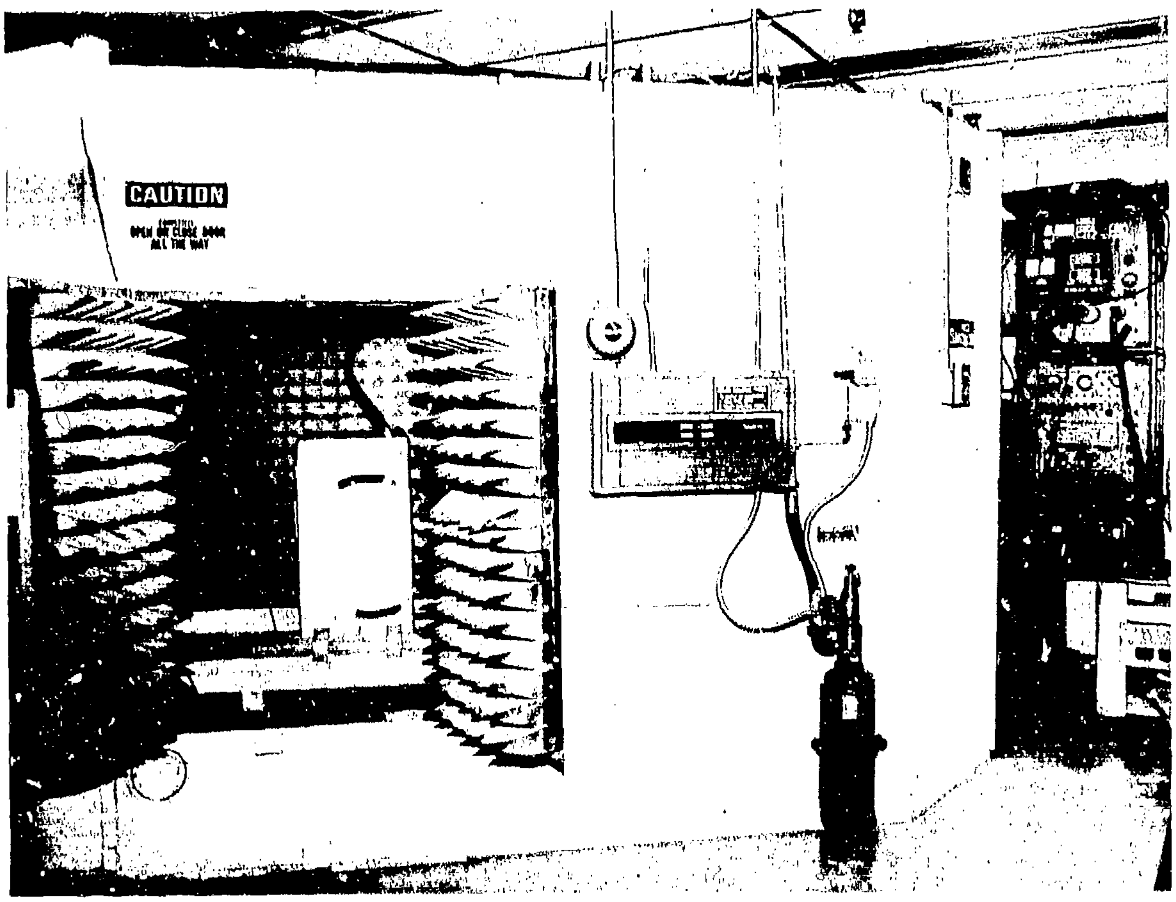


Figure 7

The exercise chair, with a rhesus monkey restrained in it, inside a microwave-anechoic chamber. The chair is strapped to the rails with Velcro. A food pellet feeding tube delivers pellets to the monkey from an outside feeder.

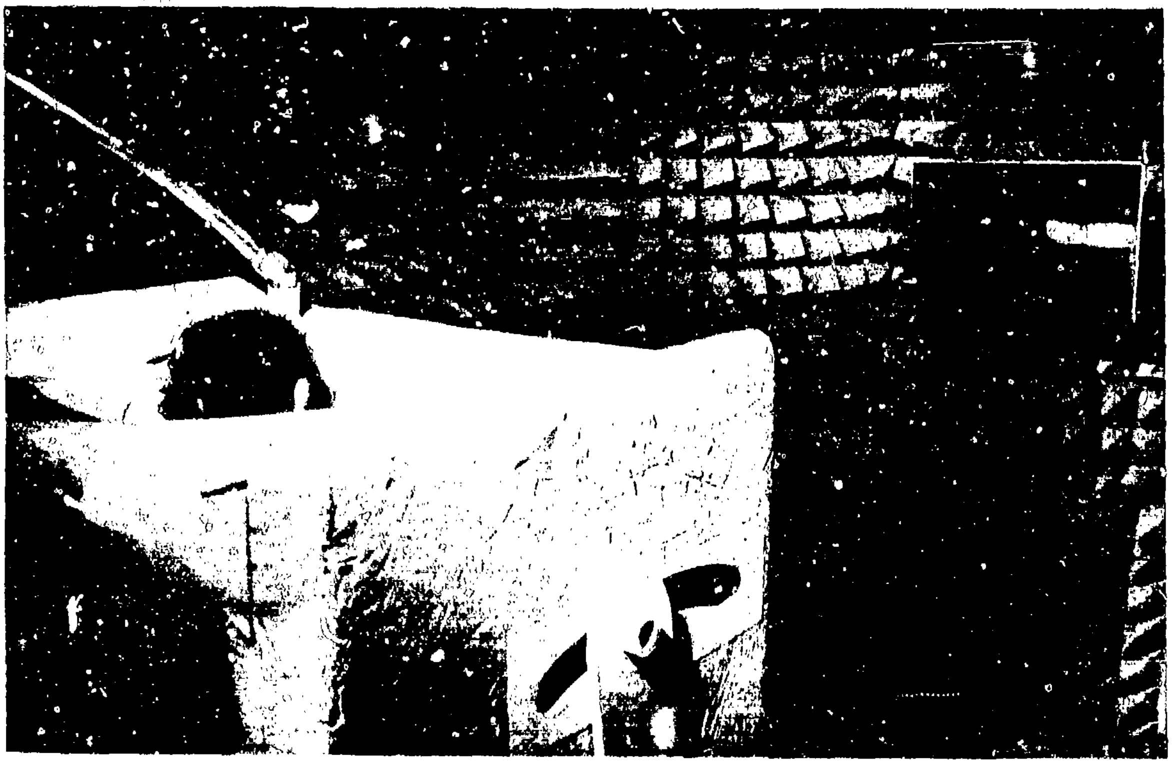


Figure 8

Inside the microwave chamber showing the radiation horn, monkey, feeding tube and exercise chair as they are positioned for an experimental session.

Exercise components of each behavioral period (see Figure 5) consisted of either a series of three increasing work loads or a series of three decreasing ones. Three different work loads were obtained by connecting one, two, or three springs to the sliding bar. If an experimental session required exercise with increasing work loads, component 2 of the behavioral period was with one spring, component 4 with two springs, and component 6 with three springs. Reel spring changes were made during extinction components 3 and 5. The decreasing series of work loads reversed this order.

Animal colonic temperature was measured from a thermistor probe inserted 10 cm past the anal sphincter and heart rate derived from skin electrodes taped to the monkey's back and tail (see Figure 9).

The example experiment and body area microwave power density measurements gave results that demonstrate reasonable confidence in the Styrofoam exercise chair as a tool for microwave investigations. A number of psychological and physiological measures made during microwave irradiation in combination with different experimental configurations are possible with this device.

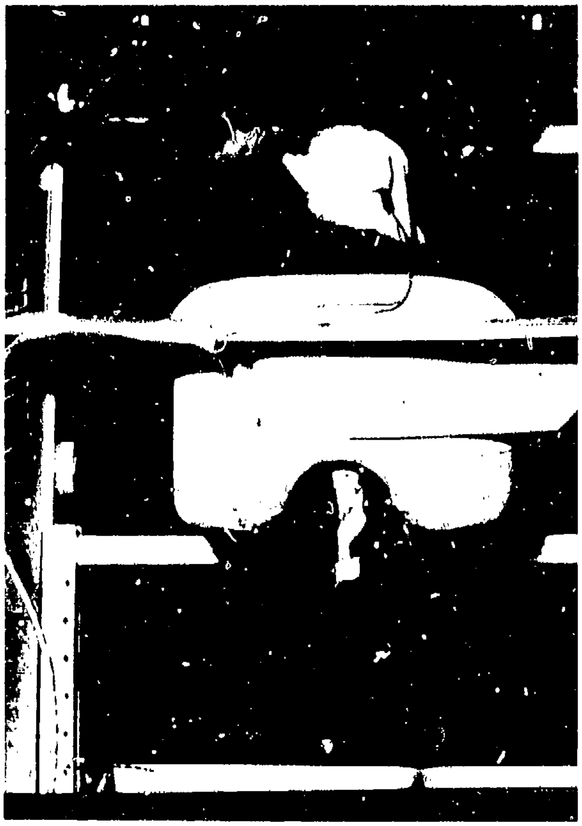


Figure 9

Monkey instrumented for heart rate recording with one electrode taped to the back and another to the tail.

Figure 10 illustrates base-line session data of subject 15R's mean colonic temperature, heart rate, correct responses, and post-reinforcement pause time (PRfPT). Colonic temperature rose remarkably from pre-session base line during the first exercise component (0.3 °C for increasing work load and 0.4 °C for decreasing work load) and then leveled off at 0.6 °C for increasing work load and 0.5 °C for decreasing work load. Heart rate and correct responses varied with work load but in opposite directions; heart rate varied directly, responses inversely. Figure 10 shows subject 15R's PRfPT results that give the mean number of seconds between a food pellet delivery and the next correct response. Only slight variations appear in post-reinforcement pause times.

At the writing of this report there have been at least 875 one-hour sessions of the prototype chair's use in control and irradiation sessions similar to that of the above example experiment. During that time six reel spring cables broke and were replaced and Styrofoam surfaces at the top of the chair were coated with epoxy as the monkeys made inroads with their fingers. Monkeys weighing 2.5 to 4 kg have been used but larger ones may be accommodated by the chair since both the foot bar and seat

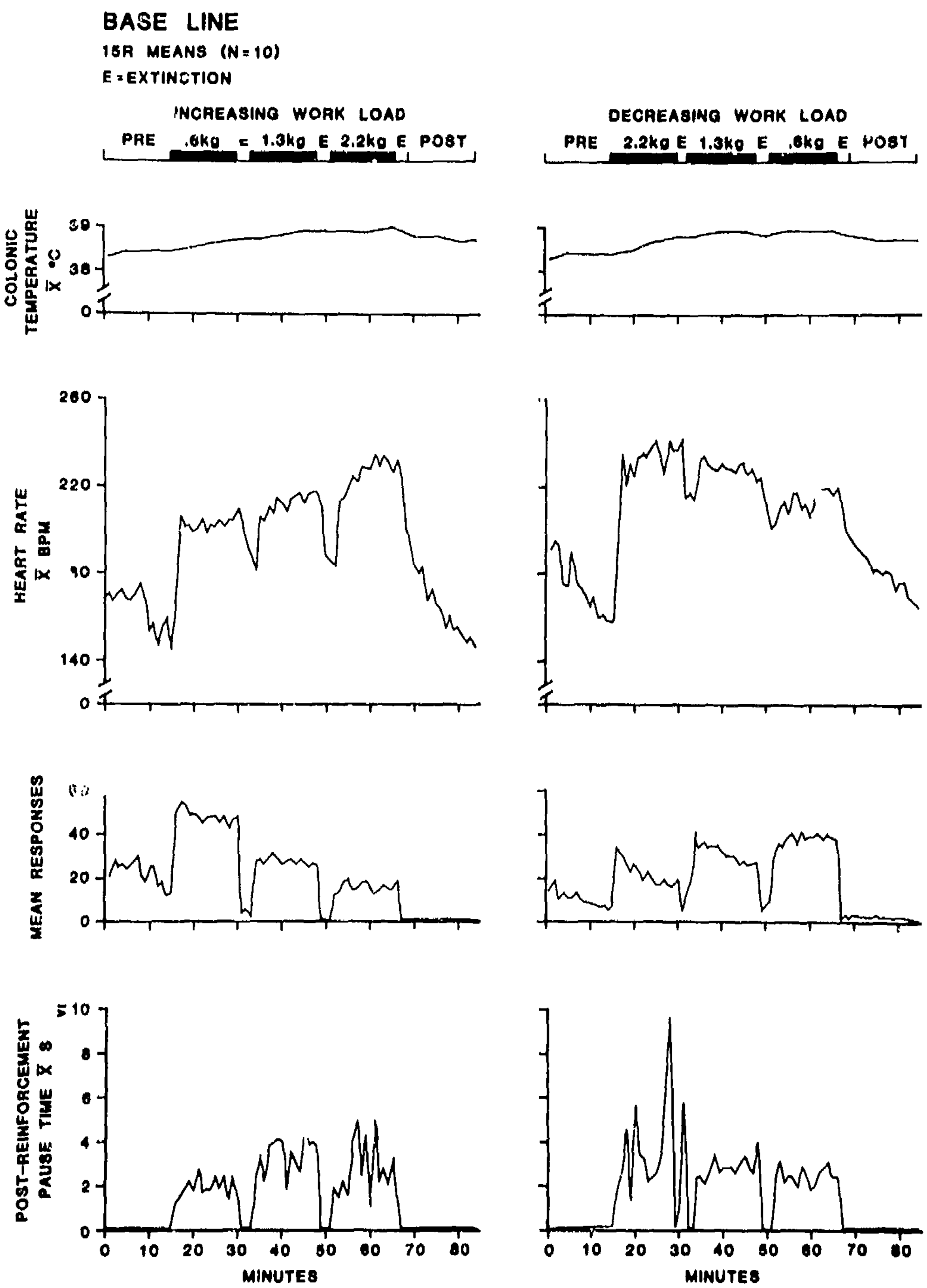


Figure 10

Mean colonic temperature, heart rate, response, and post-reinforcement pause time (PRfPT) results of base-line sessions by rhesus monkey 15R. PRfPT is the time between a food pellet delivery and the next correct response.

are adjustable (see Figures 2 & 3). Monkeys quickly (usually within 5 one-hour sessions) produce complete rowing-movements when conditioned by feeding a food pellet only after executing behaviors that contribute to that movement. (A tone always signalled the end of a full rowing-movement). The monkeys were kept at 85-90% of their base-line body weight which effected an adequate work rate. They received no other food except fruit during an experiment day. At the beginning of exercise training minimal work load (rubber bands of various sizes) was used and then increased to the desired force level with springs. To prevent removal of the colonic temperature probe it was secured to the depilated tail base with tape. "Chairing" of the monkey was always done by a single person and consideration of seat position mainly made to assure proper rowing-movement by the animal without injury to him. Even though we have not maintained monkeys for extended periods of time in the microwave-exercise restraint chair, it is conceivable that such chronic treatment would not cause edema or psoriasis-like symptoms in the feet and legs, or decubital ulcers in and around their ischial callosities. Those conditions have been reported (3, 11, 14, 23) when using restraint chairs without an exercise capability for lengthy experiments of several weeks or months.

Since the basic relationship of the monkey to the parts of the chair had already been resolved by others (14, 17, 18, 23), main design consideration had to take into account a) maximum exposure of animal to microwaves, and b) a rowing-movement by the animal that would produce adequate physiological and behavioral effects. As seen in Figure 3a separate handles have the seated monkey reasonably exposed to irradiation of his front side. Exercise effects were gained both by positioning the pivoted point of each lever and making each lever's length such that sufficient work was done without compromising the animal's apparent comfort or efficiency. Placement of the work load depended upon experimental requirements.

The vertical scan microwave power density measurements revealed a disturbance in the microwave field distal to the chair. This situation is unlike that found by Reno _et al_ (17, 18). In scanning behind their Styrofoam restraint chair they found only slight power differences with and without the chair. It is probable that the necessity for maximum ridgity (furnished by high impact styrene) at more points on the exercise chair caused an increased perturbation of the microwave field. The body-position power measures revealed only slight with-/without-chair differences and are similar to those made by Reno _et al_ (17, 18).

In order to have an adequate idea of the power expended by an animal during exercise on this task it would be necessary to conduct an indirect calorimetric study. This would require an addition to the exercise chair of a hood over the monkey's head. Oxygen (O_2) and carbon dioxide (CO_2) concentrations of both the influx and efflux gas could then be monitored with O_2 and CO_2 analyzers and O_2 uptake ($\dot{V}O_2$) and CO_2 production ($\dot{V}CO_2$) taken as the product of the flow rates (STPD) and the differences in influx-efflux O_2 and CO_2 concentrations. This basic system has been used in metabolic studies with squirrel monkeys (_Saimiri sciureus_) (1, 12, 21) and rhesus monkeys (4, 13, 19). With the metabolic rate known, meaningful relationships could be made with other parameters; such as, heart rate, colonic temperature, response rate, and both behavioral topographical characteristics and transitions. As the chair is presently designed, only a minimum idea of exercise power can be gained by calculations using spring force extension and response values. These calculations serve only as a guide to understanding the above relationships; moreover they do not satisfy questions that arise when determining novel environmental effects. For instance, the microwave effect on heart rate could be narrowed to metabolic or other causes with the use of a hooded Styrofoam exercise restraint chair.

Complicated interactions of psychological and physiological systems in a nonionizing irradiation environment are amenable to studies using the Styrofoam exercise chair. Figure 10 gives some idea of the degrees of interaction between contingencies of scheduled work load, heart function, motor response and colonic temperature. With the addition of sophisticated micro- and macro-catheterization and electrode techniques and increased work load, computer analyses of all the data could elucidate general complex physiological and psychological interacting mechanisms, e.g., temperature regulation, cardiovascular dynamics, neuroendocrine balance, ionic changes, electrolyte chemistry balance, behavioral characteristics, etc. The liminal effects of electromagnetic waves may be evident to a marked degree after comparsion of such analyzed data with similar control information. The persuance of knowledge regarding the broad normal and perturbed interrelations of body systems has been recently considered by Michaelson (15) and by Adolph (2).

REFERENCES

1. Adair, E.R. and Adams, B.W., Adjustments in metabolic heat production by squirrel monkeys exposed to microwaves. J. Appl. Physiol.: Respirat. Environ. Exercise Physiol., 52 (4): 1049-1058, 1982.

2. Adolph, E.F., Physiologic integrations in action. Supplement to The Physiologist, 25 (2): v + 67 pages, 1982.

3. Braun, R.G., Wolfle, T.L. and Chisum, J.A., A footrest-leg exercise device for long-term restraint studies with primates. J. Exper. Anal. Behavior, 11:69-70, 1968.

4. Chaffee, R.R. and Allen, J.R., Effects of ambient temperature on resting metabolic rate of cold - and heat-acclimated Macaca mulatta. Comp. Biochem. Physiol., 44A: 1215-1225, 1973.

5. Curran, C.R., Wiegel, W.R., and Stevens, D.N., Design and operation of an exercise device for subhuman primates. AFRRI TN72-1. Bethesda, MD: Armed Forces Radiobiology Research Institute, 1972.

6. de Lorge, J., A technique for producing calisthenic behavior in a rhesus monkey. NAMRL-1124. Pensacola, FL: Naval Aerospace Medical Research Laboratory, 1970.

7. de Lorge, J., and Thach, J.S. Jr., Rhesus monkey heart rate during exercise. NAMRL-969. Pensacola, FL: Naval Aerospace Medical Research Laboratory, 1972.

8. Dews, P.B. and Herd, J.A., Behavioral activities and cardiovascular functions: effects of hexamethonium on cardiovascular changes during strong sustained static work in rhesus monkeys. J. Pharmacol. and Exper-therap. 189 (1): 12-23, 1974.

9. Gaide, M.S., Heart rate and blood pressure responses in aversively versus appetitively conditioned rhesus monkeys during classical conditioning and exercise. Ph.D. dissertation. Coral Gables, FL: The University of Miami, 1978.

10. Gisolfi, C.V., Mora, F. Nattermann, R., and Myers, R.D., New apparatus for exercising a monkey seated in a primate chair. J. Appl. Physiol: Respirat. Environ. Exercise Physiol. 44: 129-132, 1978.

11. Grissett, J.D., Kupper, J.L., Kessler, M.J., Brown, R.J., Prettyman, G.D., Cook, L.L, and Griner, T.A., Exposure of primates for one year to electric and magnetic fields associated with ELF communications systems. NAMRL-1240. Pensacola, FL: Naval Aerospace Medical Research Laboratory, 1977.

12. Horstman, D.H. and Banderat, L.E., Hypoxia-induced metabolic and core temperature changes in the squirrel monkey. J. Appl. Physiol. 42: 273-278, 1977.

13. Johnson, G.S. and Elizondo, R.S., Thermoregulation in Macaca mulatta: a thermal balance study. J. Appl. Physiol: Respirat. Environ. Exercise Physiol. 46: 268-277, 1979.

14. Mason, J.W., Restraining chair for the experimental study of primates. J. Appl. Physiol. 12: 130-133, 1958.

15. Michaelson, S.M., Physiologic regulation in electromagnetic fields. Bioelectromagnetics 3: 91-103, 1982.

16. Randall, D.C. and Smith, O.A., Ventricular contractility during controlled exercise and emotion in the primate. Amer. J. Physiol. 226 (5): 1051-1059, 1974.

17. Reno, V.R. and de Lorge, J.O., A primate-restraint device for use in microwave biological research. IEEE Transactions Biomedical Engineering. 17: 201-203, 1977.

18. Reno, V.R., de Lorge, J.O., Prettyman, G.D., Ezell, C.S., and Griner, T.A., A primate restraint chair for use in microwave radiation studies. NAMRL-1211. Pensacola, FL: Naval Aerospace Medical Research Laboratory, 1974.

19. Robertshaw, D., Taylor, C.R., and Mazzia, L.M., Sweating in primates: secretion of adrenal medulla during exercise period. Amer. J. Physiol. 224 (3): 678-681, 1973.

20. Smith, O.A. Jr., King R. L., Rushmer, R.F., and Ruch, T.C., Techniques for determination of cardiovascular response to exercise in unanesthetized monkeys. J. Appl. Physiol. 17: 718-721, 1962.

21. Stitt, J.T. and Hardy, J.D., Thermoregulation in the squirrel monkey (Saimiri sciureus) J. Appl. Physiol. 31 (1): 48-54, 1971.

22. Ternes, J.W. and Farrer, D.N., A circadian rhythm in the rhesus monkey. ARL-TR-66-21. Holloman Air Force Base, NM: 6571st Aeromedical Research Laboratory, 1966.

23. Young, F.A., A primate control system. Proc. Animal Care Panel 7:127-137, 1957.

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Restraint chair, exercise, nonhuman primates, microwaves

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Design and construction of a Styrofoam exercise restraint chair is described for use with rhesus monkeys exposed to microwaves. Monkeys usually learn the rowing-like motion of the device within five 1-hour conditioning sessions. Radiation intensity measure of the chair and an example animal experiment demonstrated the chair's suitability for bioelectromagnetic studies. Results of a series of base-line behavioral sessions demonstrated concomitant exercise work load effects on colonic temperature heart rate, correct response

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) rate, and post-reinforcement pause time. With additional instrumentation, detection of minute disturbances of intergrated psychological and physiological mechanisms by unusual environmental factors may be possible.